MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XLV. MAY 8, 1885. No. 7

EDWIN DUNKIN, F.R.S., President, in the Chair.

Professor C. H. Brewitt Taylor, Foo-Chou Arsenal, China, was balloted for and duly elected a Fellow of the Society.

The Astronomer Royal desires to give notice that having several spare copies of Col. Tennant's "Report on the Transit of *Venus*, 1874" in stock at the Royal Observatory, he will be willing to present copies to any Fellows of the Society who may wish for them, on their making application to him for the same.

On the Right Ascensions of the Cape Catalogues, 1850, 1860, *and* 1880. By E. J. Stone, M.A., F.R.S.

The comparisons which Mr. Downing has made between the Right Ascensions of the Cape Catalogue, 1880, and those of the Melbourne Catalogue for 1870 (*Monthly Notices*, March 1885, page 301), is some real test of the freedom of the Catalogues compared from systematic errors. The epochs of the two Catalogues are only separated by ten years, and, in most cases, material exists for an approximate determination of the proper motions of the stars. It will be seen that the result justifies the statement which I made in *Notices*, January 1885, that the Right Ascensions made with the Transit Circles of the Melbourne and the Cape were either free from systematic errors, or affected with sensibly equal errors depending upon N.P.D.

But the comparisons which Mr. Downing has made between the Right Ascensions of the Cape Catalogues, 1850, 1860, and 1880, cannot be regarded as reliable tests of the existence of systematic errors in these Catalogues.

This is not due to any want of care or skill on Mr. Down-

ing's part, but to the absence of reliable data. It is impossible to determine the proper motions of the Southern stars contained in these Catalogues with sufficient accuracy to allow the Right Ascensions of the stars to be brought up over periods of twenty or thirty years with a precision which will justify the assumption that differences thus found are due to instrumental defects. For my own part I seriously doubt the legitimacy of such assumptions for the much more frequently observed stars within the reach of our principal northern observatories; and the conclusion to which Mr. Downing has been led (*Notices*, March 1885, page 315), that the proper motions of the clock-stars are not yet sufficiently well determined to allow of their Right Ascensions being brought up for a period of twenty years, is, I venture to think, a sufficient justification of my doubts.

But if these comparisons between the Cape Catalogues, 1850, 1860, 1880, were reliable, then the differences which Mr. Downing has given between the Right Ascensions of the 1880 Catalogue and those for 1850 and 1860 could not be due to errors in the 1880 Catalogue dependent upon N.P.D.

For these comparisons indicate that the Right Ascensions of the Southern stars in the 1880 Catalogue are too *small* relatively to those of the stars near the Equator by about a tenth of a second of time, when compared with the Right Ascensions of the 1850 Catalogue, whilst they are *too large* by about a tenth of a second of time, when compared with the Right Ascensions in the 1860 Catalogue, in the indirect manner adopted by Mr. Downing. Now the Right Ascensions of the Cape Catalogue, 1880, may be either too small or too large, but they certainly cannot be both too small and too large.

I have no hesitation in expressing an opinion that these differences are chiefly due to imperfections in the carrying out of the comparisons.

But as the results of the Cape Catalogue, 1860, are, in my opinion, of great accuracy, and tables of differences, such as those given by Mr. Downing, may lead to false impressions of the accuracy of the results contained in the two Catalogues compared, I have thought it desirable to test the reality of the somewhat large residual difference found for the zone N.P.D. 139° to N.P.D. 156°.

I have found seventy-five stars in the Cape Catalogue for 1860 which have proper motions adopted for them in Right Ascension, in the Melbourne Catalogue, 1870; I have brought up the Right Ascensions of these stars from 1860 to 1880 with these adopted proper motions. The difference which I thus find is only $+0^s.05$. But even this small quantity would be diminished if, in the determination of the Melbourne proper motions, Powalky's re-reduction of Lacaille's observations had been used instead of the uncorrected results. I have not, however, thought it worth while to pursue the point further. Powalky has made his re-reduction differential with respect to Bradley's observations as reduced by Bessel; and as Auwers has

shown that these results require some not inconsiderable alterations, it would appear that some further modifications of Powalky's corrections must also be required. I have, however, given one other test of the accuracy of the Right Ascensions of the 1860 Catalogue. I find in the same zone eighty-four stars which are also contained in the 1840 Catalogue. I have, therefore, brought up the Right Ascensions of the 1860 Catalogue to 1880, with the proper motions found for the 1840 and 1880 Catalogues. The mean difference thus found is only $+0^{s}\cdot03$.

Such quantities as these are certainly not larger than those which will be found to result from similar comparisons between the best existing catalogues if separated by intervals of twenty years.

On the Diameters of the Sun and Moon as observed with the Greenwich Transit Circle. By W. G. Thackeray.

(*Communicated by A. M. W. Downing.*)

In one of the numerous sections of "Greenwich Observations" are yearly given the results of the comparisons of the diameters of the Sun and Moon, as computed by the *Nautical Almanac* Office, and as observed with the Greenwich Transit Circle, in the form of error of the *Nautical Almanac* diameter, and the mean of all these errors for the year, with the number of observations on which the value depends, is given in the several introductions.

A discussion of these errors, for several years previous to 1864, led to the adoption of a correction of $-0''\cdot53$ to the computed value of the *Nautical Almanac* semi-diameter of the Sun in all cases whenever a single limb only was observed, and this correction, which has continued to accord with the mean annual error year by year, has been still applied up to the present time whenever necessary. While casually looking into the observations on which this correction has been founded, I was drawn into an inquiry as to what is the mean value of the diameter of the Sun and Moon, given by all the observations made with the Greenwich Transit Circle, and what is the special value given by each of the regular observers? In other words, what is the amount of personality hidden away under this uniform annual mean?

The following Tables I. and II. are formed by extracting directly from the several volumes of "Greenwich Observations" the mean annual errors of the *Nautical Almanac* horizontal and vertical diameters of the Sun and Moon, with the number of observations on which they depend, so that the resulting value of the diameter is one which depends on a long series of observations made by various observers, and spread over a number of years.

Tables III. and IV. are formed by taking from one of the planetary sections the daily errors of the *Nautical Almanac*

vertical diameters of the Sun and Moon, as given by each of the regular observers for a period of years, and ranging them under each observer's name, and the tabular figures represent the mean annual error with the number of observations on which the value depends subscribed.

The number of observations of the double limbs of the horizontal diameter of the Moon with the Transit Circle are, unfortunately, not sufficiently numerous to afford any reliable information; but, in the case of the horizontal diameter of the Sun, Mr. Dunkin has already printed in the *Monthly Notices* several papers which exhibit the amount of personality to be expected.

TABLE I.

Apparent Errors of the Duration of Passage of the Sun's Horizontal Diameter, and of the Sun's Vertical Diameter as computed in the "Nautical Almanac."

Year.	No. of Obs. of Horizontal Diameter.	Mean Value of N.A.—Obs. s	No. of Obs. of Vertical Diameter.	Mean Value of N.A.—Obs. ″
1861	108	+0·10	113	+0·97
1862	81	+0·13	87	+1·11
1863	103	+0·12	107	+1·29
1864	105	+0·08	111	+1·09
1865	104	+0·07	117	+1·02
1866	95	+0·08	103	+1·11
1867	73	+0·11	83	+1·39
1868	111	+0·08	126	+1·33
1869	79	+0·12	93	+1·60
1870	106	+0·12	119	+1·29
1871	103	+0·11	104	+0·65
1872	107	+0·12	109	+0·64
1873	102	+0·11	108	+0·49
1874	94	+0·10	95	+0·17
1875	96	+0·11	104	+0·59
1876	99	+0·11	96	+1·03
1877	75	+0·10	75	+1·02
1878	77	+0·10	72	+1·34
1879	61	+0·09	64	+1·33
1880	99	+0·08	104	+1·38
1881	107	+0·09	108	+0·93
1882	87	+0·08	97	+0·68
1883	113	+0·05	122	+0·87

Weighting these results according to the number of observations in each year, and remarking that in the case of the duration of the passage of the horizontal diameter we shall not be much in

error in multiplying by 14 to convert into seconds of arc, we obtain

Period.	No. of Obs. of Horizontal Diameter.	Mean Value of N.A.—Obs.	No. of Obs. of Vertical Diameter.	Mean Value of N.A.—Obs.
		s		″
1861–83	2185	+0·097	2317	+1·00
		or +1″·36		

Remarking that the assumed value of the *Nautical Almanac* diameter of the Sun at the Earth's mean distance has been 32′ 3″·64 since 1853, and changing the sign of the errors to obtain the corrections, we get

Period.	No. of Obs.	Corrected Hor. Diam.	No. of Obs.	Corrected Vert. Diam.
		′ ″		′ ″
1861–83	2185	32 2·28	2317	32 2·62

In vol. 22 of the *Monthly Notices*, in a paper entitled 'On the Circularity of the Sun,' Sir G. B. Airy obtained the following results from the diameter:—

Period.	No. of Obs. Hor. Diam.	Corrected Hor. Diam.	No. of Obs. Vert. Diam.	Corrected Vert. Diam.
		′ ″		′ ″
1853–60	795	32 2·65	851	32 2·61

Combining the two results together, and weighting them according to the number of observations, we finally obtain

		′ ″		′ ″
1853–80	2980	32 2·38	3168	32 2·62

It seems curious that the values of the vertical diameter for the two periods 1853-60 and 1861-83 should be nearly identical, while those of the horizontal diameter should differ by 0″·37; but this difference may with great probability be ascribed to a change in the observing staff, and the consequent change in the mean value of the personality of all the observers. As it may be instructive to trace the changes made in the staff of the Observatory, we therefore record, as shortly as possible, the history bearing on this point.

In 1853, the Rev. R. Main was chief assistant, and the other assistants were Messrs. Henry, Dunkin, Breen, Ellis, and Todd. Mr. Breen superintended the computers and virtually did no observing.

In 1854, Mr. Todd resigned, and was succeeded by Mr. Criswick.

In 1857, Mr. Henry died, and was replaced by Mr. Lynn.

In 1859, Mr. Breen resigned, and Mr. Lynn superintended computers and virtually did no observing, and Mr. James Carpenter was appointed an assistant.

In 1860, Mr. Main resigned, and Mr. Stone was appointed in his place, and no change took place in the staff till,

In 1870, Mr. Stone resigned, and Mr. Christie took his place. Mr. Dunkin was made superintendent of computers and did no observing, and Mr. Lynn became an observing assistant.

In 1873, Mr. Downing was appointed in the place of Mr. James Carpenter, who resigned, and Mr. Maunder was appointed physical assistant.

In 1875, Mr. Thackeray succeeded Mr. Glaisher, who resigned, and Mr. Ellis was transferred to superintend the Magnetical and Meteorological Observatory.

From 1877 till 1880, Mr. Lynn was ill and did little or no observing, so that a great many more computers than usual were employed in making observations.

In 1881, Mr. Lewis succeeded Mr. Lynn, who resigned in 1880.

In 1882, the vacancy caused by the appointments of Mr. Christie and Mr. Dunkin to be respectively Astronomer Royal and Chief Assistant, was filled up by Mr. Hollis, and Mr. Criswick was made superintendent of computers, and ceased to be an observing assistant. Since that time the staff has remained the same.

We may fairly assume therefore that the mean value of the two diameters, viz., $32'\ 2''{\cdot}5$, would very accurately represent the diameter of the Sun as seen in the Greenwich Transit Circle by a being whom we will designate for want of a better name, a "mean observer."

TABLE II.

Apparent Errors of the Duration of Passage of the Moon's Horizontal and Vertical Diameter as computed in the "Nautical Almanac."

Year.	No. of Obs. Hor. Diam.	Mean Value of N.A.−Obs.	No. of Obs. Vert. Diam.	Mean Value of N.A.−Obs.	Mean N.A. Diameter.
		s		″	′ ″
1856	3	−0·05	13	−2·02	31 9·22
1857	3	+0·13	11	+1·03	31 9·36
1858	5	+0·07	15	+0·92	... ...
1859	4	+0·14	16	+2·39	... ...
1860	1	+0·05	9	+2·11	... ...
1861	2	+0·11	10	+0·93	... ...
1862	2	+0·08	1	+0·25	31 8·20
1863	3	+0·02	7	−1·43	... ...
1864	2	+0·06	5	−0·49	... ...
1865	4	+0·08	7	+0·03	.. ...
1866	2	+0·09	7	+0·81	... ...
1867	3	+0·17	2	−0·09	... ...
1868	4	−0·03	13	+0·90	... ...
1869	2	−0 03	4	+1·31	... ...
1870			5	−0·36	... ...
1871	2	+0·04	7	+0·72	... ...
1872	2	−0·03	5	−1·34	... ...
1873	2	+0·08	8	+0·27	... ...
1874	2	−0·03	12	−1·41	... ...

Year.	No. of Obs. Hor. Diam.	Mean Value of N.A.—Obs.	No. of Obs. Vert. Diam.	Mean Value of N.A.—Obs.	Mean N.A. Diameter.
		s		"	′ "
1875	2	+0·17	8	+0·49	... ...
1876	4	+0·17	3	−3·62	... ...
1877	2	+0·05	9	−0·99	... ...
1878	1	−0·20	6	+0·83	... ...
1879	1	+0·12	8	−0·16	... ...
1880	2	+0·01	14	−0·29	... ...
1881	2	+0·06	14	−0·45	... ...
1882	4	−0·03	21	−0·19	... ...
1883			11	−0·84	... ...

Grouping these figures according to the different values of diameter, we obtain

Period.	No. of Obs. Hor. Diam.	Mean Value of N.A.—Obs.	No. of Obs. Vert. Diam.	Mean Value of N.A.—Obs.	Mean N.A. Diameter.
				"	′ "
1856	3	−0ˢ·050 or −0″·70	13	−2·02	31 9·22
1857–61	15	+0ˢ·105 or +1″·47	61	+1·38	31 9·36
1862–83	48	+0ˢ·049 or +0″·69	187	−0·25	31 8·20

Since 1862, Hansen's Tables have been used in the *Nautical Almanac*, and taking the value of the Moon's semi-diameter as given by Hansen =num. (log = 4.750519) × sin(parallax equatorial and horizontal), and assuming the value of the mean equatorial horizontal parallax to be that given by Adams, viz., 57′ 2″·3, we find the corresponding value of the diameter to be 31′ 8″·20. Therefore, using this value, we obtain

Period.	No. of Obs. Hor. Diam.	Corrected Hor. Diam.	No. of Obs. Vert. Diam.	Corrected Vert. Diam.
		′ "		′ "
1856	3	31 9·92	13	31 11·24
1857–61	15	31 7·89	61	31 7·98
1862–83	48	31 7·51	187	31 8·45

Combining these results together, we finally obtain

1856–83	66	31 7·71	261	31 8·48

Considering the number of observations and the difficulties under which these observations are frequently made, one of the limbs being generally more or less rugged and defective in illumination, the agreement is as near as can be expected, and tends to prove that the value of the diameter as used in the *Nautical Almanac* is very satisfactory.

TABLE III.

Mean Annual Value of the Error of the Vertical Diameter of the Sun as computed in the "Nautical Almanac."

Year.	Dunkin.	Ellis.	J. Carpenter.	Criswick.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.
	"	"	"	"	"	"	"	"	"
1861	$+2''.33_{14}$	$-0''.14_{18}$	$+1''.93_{9}$	$+0''.92_{19}$					
1862	$+1''.62_{7}$	$-0''.18_{15}$	$+2''.55_{14}$	$+1''.19_{15}$					
1863	$+2''.23_{16}$	$+0''.24_{26}$	$+3''.21_{21}$	$+1''.02_{19}$					
1864	$+2''.37_{17}$	$-0''.67_{21}$	$+3''.31_{19}$	$+1''.19_{27}$					
1865	$+2''.32_{18}$	$-0''.63_{26}$	$+2''.71_{19}$	$+1''.68_{28}$					
1866	$+2''.34_{18}$	$-0''.22_{19}$	$+2''.48_{19}$	$+1''.31_{16}$					
1867	$+2''.16_{15}$	$-0''.17_{19}$	$+2''.57_{14}$	$+2''.35_{14}$					
1868	$+2''.28_{19}$	$-0''.49_{20}$	$+2''.78_{14}$	$+1''.59_{22}$					
1869	$+2''.50_{14}$	$-0''.21_{18}$	$+4''.68_{13}$	$+1''.73_{17}$					
1870		$-0''.83_{9}$	$+3''.97_{22}$	$+1''.46_{20}$	$-0''.96_{19}$				
1871		$+0''.17_{15}$	$+3''.99_{13}$	$+1''.74_{17}$	$-1''.99_{28}$				
1872		$+0''.49_{22}$	$+2''.96_{14}$	$+1''.93_{17}$	$-1''.75_{23}$				
1873		$+0''.61_{18}$		$+1''.13_{15}$	$-1''.26_{20}$	$+0''.22_{27}$			
1874		$-0''.16_{13}$		$+1''.99_{15}$	$-1''.79_{20}$	$+0''.46_{5}$			

Year.	Dunkin.	Ellis.	J. Carpenter.	Criswick.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.
	"	"	"	"	"	"	"	"	"
1875				$+2\cdot55_{15}$	$-1\cdot14_{10}$	$+1\cdot13_{14}$	$+1\cdot41_{12}$		
1876				$+2\cdot33_{14}$	$-1\cdot23_{9}$	$+1\cdot79_{19}$	$+0\cdot45_{18}$		
1877				$+2\cdot86_{10}$		$+2\cdot46_{11}$	$-0\cdot59_{12}$		
1878				$+1\cdot86_{10}$		$+2\cdot72_{16}$	$-0\cdot08_{9}$		
1879				$+2\cdot06_{11}$		$+2\cdot11_{14}$	$+2\cdot09_{9}$		
1880				$+1\cdot50_{15}$		$+2\cdot26_{25}$	$+1\cdot37_{19}$		
1881				$+1\cdot96_{15}$		$+2\cdot31_{22}$	$+1\cdot42_{17}$	$-0\cdot26_{23}$	
1882						$+1\cdot47_{14}$	$+0\cdot89_{21}$	$+0\cdot81_{18}$	$-0\cdot18_{25}$
1883						$+2\cdot45_{21}$	$+1\cdot51_{24}$	$+1\cdot01_{21}$	$+0\cdot59_{19}$
Means	$+2\cdot28_{138}$	$-0\cdot19_{269}$	$+3\cdot13_{191}$	$+1\cdot65_{347}$	$-1\cdot59_{149}$	$+1\cdot70_{203}$	$+1\cdot01_{141}$	$+0\cdot48_{62}$	$+0\cdot15_{44}$
Probable error of Means	±0·068	±0·065	±0·063	±0·041	±0·087	±0·055	±0·068	±0·1143	±0·1441
Probable error of a single obs.	±0·799	±1·066	±0·871	±0·764	±1·062	±0·784	±0·807	±0·900	±0·934

Mean of all observers ... ... $+1\cdot11_{1544} \pm 0\cdot0221$

From these figures it seems clear that the value of the diameter, as depending on the several observers, varies very considerably, the difference in the case of Mr. Lynn and Mr. Carpenter amounting to nearly 5″. The − sign denotes that the micrometer wire is placed by the observer outside, and the + sign, that it is placed within the limbs, as represented by the *Nautical Almanac* diameter. The error, as given by the same observer, varies somewhat from year to year, so that the system adopted at the Washington Observatory in cases of the observation of a single limb, of correcting the diameter from the mean error of all the observations made during the year by the same observer, is preferable to a uniform correction from the mean of all the observers, for in some cases such a correction only aggravates the error it was meant to remedy.

In vol. xxxv., p. 91, of the *Monthly Notices*, Mr. Dunkin has represented the tabular error of the duration of the horizontal diameter of the Sun for the ten years 1864-73 to be as follows:—

Period.	Dunkin.	Ellis.	Criswick.	Lynn.	J. Carpenter.
	s	s	s	s	s
	+0·062	+0·106	+0·022	+0·075	+0·175
1864–73	or	or	or	or	or
	″	″	″	″	″
	+0·87	+1·48	+0·31	+1·05	+2·45

Comparing these values with those obtained for the vertical diameter, there appears to be a smaller amount of personality, the greatest difference amounting to a little more than 2″. Mr. Carpenter develops the same strong individuality, and Mr. Lynn reverses the sign of his error, so that his vertical and horizontal diameters differ in value by as much as 2″·64. Assuming that the number of observations made by each of these observers for this period is much the same, the mean error from all the observers would be +1″·23, and taking the mean of the same five observers for observations of the vertical diameter, the mean error is +1″·13, a result which is practically identical with the first.

TABLE IV.

Apparent Errors of the Vertical Diameter of the Moon as computed by the "Nautical Almanac.

Year.	Dunkin.	Ellis.	Criswick.	J. Carpenter.	Lynn.	Downing.	Thackeray.	Lew
	"	"	"	"	"	"	"	
1862		$+0.25_1$						
1863	-0.95_2		$+1.03_2$	$+0.48_1$	-3.25_1			
1864		-1.61_1	$+3.06_1$	$+0.48_1$				
1865	-0.72_2		$+1.27_2$	$+1.32_1$				
1866	$+0.88_1$	-0.49_3	$+1.11_1$	$+2.56_2$				
1867		-1.11_1	$+0.93_1$					
1868	$+0.32_2$	-1.46_1	$+1.23_4$	$+1.51_5$				
1869			$+1.28_4$					
1870			-2.37_1	$+1.60_1$	-3.64_2			
1871		$+0.39_2$	$+1.36_2$					
1872		-1.24_1	$+0.09_2$		-3.32_2			
1873		$+1.62_1$	-2.01_2		-6.10_1	$+2.02$		

Year.	Dunkin.	Ellis.	Criswick.	J Carpenter.	Lynn.	Downing.	Thackeray.	Lewis.	Hollis.
1874	"	$-0''.17_6$	$-1''.49_2$		"	$-2''.28_3$	"	"	"
1875			-1.80_1		-4.48_1	-0.08_3	$+2.24_1$		
1876							-3.90_2		
1877			-0.33_1		-1.13_2	-0.31_1	-2.54_2		
1878			$+3.08_2$			-3.27_1	$+1.61_1$		
1879			-0.23_6				$+0.74_1$		
1880			-0.18_4			$+0.05_5$	-0.83_3		
1881			$+0.79_4$			-1.69_3	-0.05_3	-1.92_2	
1882						-0.98_5	$+0.89_5$	-1.68_3	-0.83_3
1883						$+0.41_2$	$+0.36_2$	-2.69_3	$+0.09_2$
Means	-0.27_7	-0.31_{17}	$+0.46_{42}$	$+1.59_{11}$	-3.34_9	-0.72_{24}	-0.29_{20}	-2.12_8	-0.47_5
Probable error of Means	± 0.3817	± 0.2768	± 0.1526	± 0.2206	± 0.3968	± 0.2454	± 0.2535	± 0.3167	± 0.5998
Probable error of a single obs.	± 1.010	± 1.141	± 0.977	± 0.732	± 1.191	± 1.202	± 1.131	± 0.895	± 1.341

Mean of all the observers ... ... $-0''.31_{143} \pm 0''.0872$.

In forming these tables, three observations in which the errors exceed 6″ were rejected, one by Mr. Dunkin in 1863 (−7″·39), and two by Mr. Downing in 1873 and 1874 respectively (+7″·27) and (−6″·15).

The resulting errors again point to large personalities in the measurement of the diameter of the Moon as in the case of the Sun, and Mr. Lynn and Mr. Carpenter again differ in their values by nearly 5″·.

Though these results are not entitled to the same value as those of the Sun, on account of the much fewer number of observations, yet taken in connection with those of the Sun, they indicate a very definite and systematic error, as peculiar to an observer as a rate is to a chronometer, and one from which there seems to be no method of escape.

While this personality does not affect the tabular place of the Sun, as the process of taking the mean of the limbs eradicates the mischief, in the course of a lunation the quantities involved seem to be of sufficient magnitude to seriously affect the value of the tabular errors derived from the observations of the Moon.

A Note of an Observation during the Transit of Jupiter's Satellite IV., April 18. By Edmund J. Spitta.

The greater portion of this transit was observed here, both with the 10-inch reflector and three-inch Tulley refractor. Definition fair; temperature 54 F.; barometer 30·14.

The satellite for the greater part of the transit appeared black, as it commonly does; but what I should like to call attention to is, that this blackness remained until egress, *instead of disappearing about ten minutes before*—an observation I believe unique, and seen also by Mr. Gledhill of Bermerside, as well as others.

Further than this nothing unusual occurred, excepting that for about half an hour, between 11 and 11.30, the satellite became exceedingly faint, appearing to me, at times of good definition, irregularly elongated parallel to the belts, assuming then more of a chocolate colour. (Mr. Gledhill also noticed the faintness and ill-defined appearance at the same hour.) I was also struck by the faint appearance both before and after transit of this satellite as compared with the others; and, to use an expression once employed by Dawes, "it was far from obvious."

I may add that Satellite III., during a dark transit on May 2 (temperature 46° F., barometer 29·58, definition good until the time of egress, when it became unsteady) was quite different. While dark, it appeared uniformly round, and of a deep steel colour, and about ten minutes before egress became invisible, but eventually reappeared on the limb of the planet, perfectly white and defined, during good moments of definition.

Ivy House, Clapham Common:
1885, *May* 4.

Total Solar Eclipses Visible in the British Isles 878—1724.

By J. Maguire.

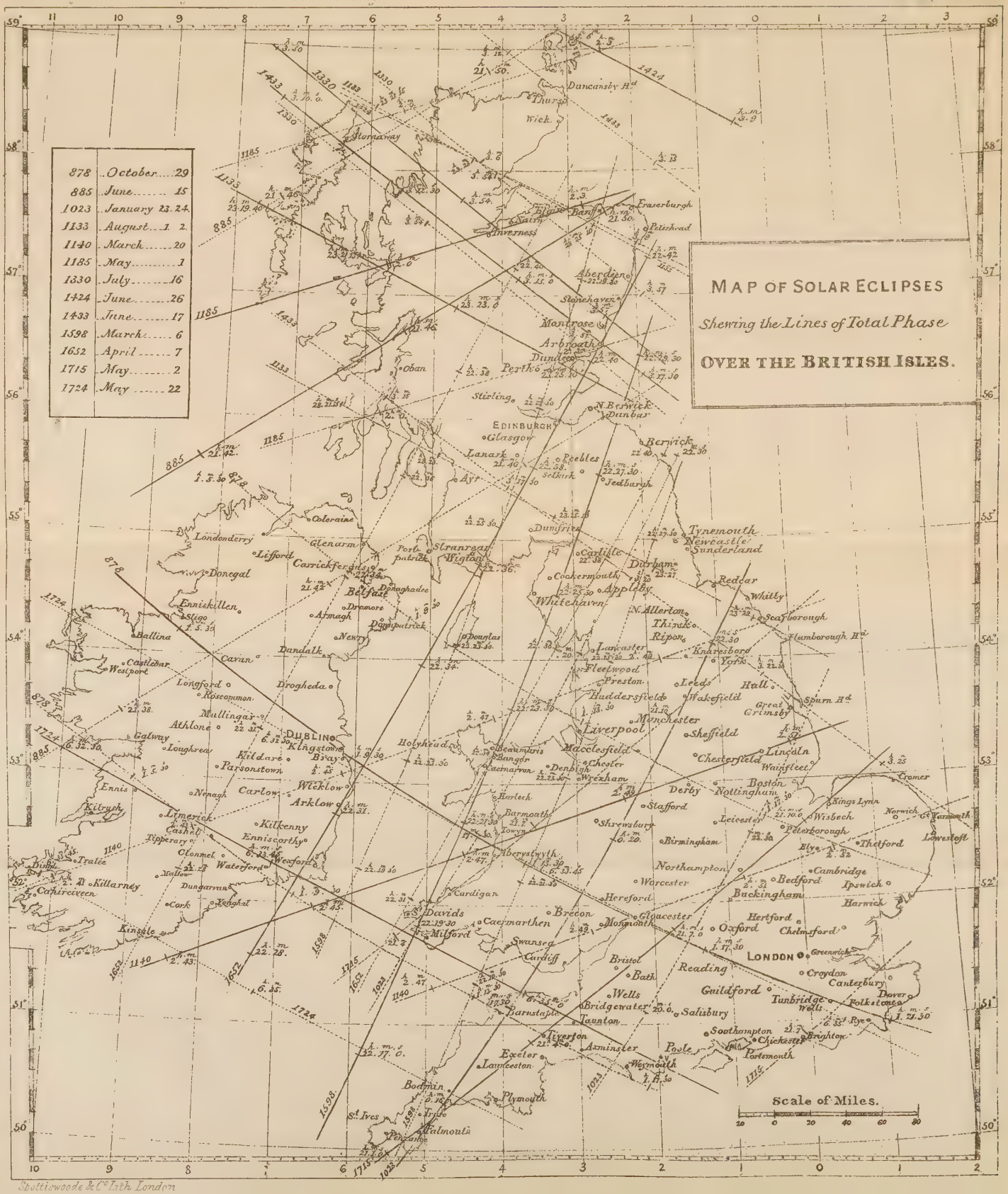
About ten years ago I calculated several if not all the total solar eclipses the central lines of which have touched the British Isles, beginning with the year 878 and ending with 1724. I used Hansen's Tables of the Sun and Moon, and in some cases Leverrier's of the Sun. A small map of the British Isles, showing the central and limiting lines of thirteen eclipses accompanies this paper.

The points for which calculations have been made are marked upon the lines, together with the Greenwich mean time. The width of shadow and the duration on the central lines are given on the list which follows.

It appears from the limiting lines of these eclipses that London has been twice totally eclipsed, Dublin twice, and Edinburgh five times. And assuming the calculations to be correct, the Moon's shadow would have fallen upon every spot of the British Isles except a small space at Dingle, on the West Coast of Ireland.

Date.		G.M.T.	Width of Shadow in miles.	Duration.
		h m s		m s
878	Oct. 29	1 17 30	168	2 13
885	June 15	21 46 0	196	4 55
1023	Jan. 24	0 20 0	130	2 24
1133	Aug. 1	23 23 0	154	4 34
1140	Mar. 20	2 49 0	132	3 26
1185	May 1	2 3 0	154	4 33
1330	July 16	3 54 0	42	0 56
1424	June 26	3 6 0	168	4 14
1433	„ 17	3 15 0	194	4 27
1598	Mar. 6	22 25 30	84	1 34
1652	Apr. 7	22 34 0	122	3 0
1715	May 2	21 7 0	184	4 0
1724	„ 22	6 35 0	136	2 48

Norwich: 1885, *April.*



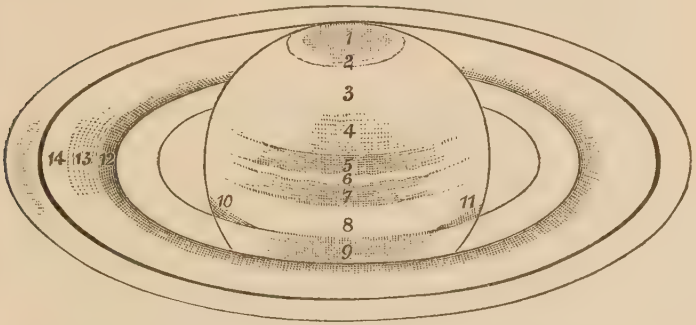
Shottiswoode & Co Lith London

Observations of Saturn. By N. E. Green.

The position of *Saturn* during the opposition now past having been most favourable for viewing the ring system, it will not be out of place to put on record the details of the planet as seen by the aid of an 18-inch reflector.

The mirror employed was figured by Mr. G. With, of Hereford, and is of the finest defining quality; the powers used varied from 250 to 400.

Many studies of the planet were made between Nov. 1884 and Feb. 1885, giving the following results:—



No. 1. South Polar cap, dark gray.
2. Very faint extension of the gray of pole, slightly yellower.
3. Broad band of yellowish-gray light.
4. Broad belt of slightly deeper colour.
5. A well marked narrow dark-gray belt.
6. Very narrow belt of yellowish light, irregular in outline.
7. The darkest belt on the ball, colour warm gray.
8. Equatorial light, very bright in the centre.
9. The edge of the dusky ring, the shade of which is increased by a dark belt on the northern side of the equatorial light. Portions of this belt are seen at 10 and 11; the resulting colour being a blue-gray darker than belt 7.

Details of Rings.

The Dusky Ring.—This extends nearly half-way from the inner edge of the inner ring to the body of the planet, and is bounded by a definite line on the edge nearest the ball.

The Inner Ring.—The inner ring is divided into three zones. The most narrow of these, No. 12, fades gradually into the dusky ring, and is warm in colour. The middle zone is the broadest, and shines with a subdued yellow light; it is bounded

distinctly by the bright zone No. 14, the most brilliant portion of the system.

Cassini's Division.—This division has varied in distinctness, being sometimes better seen either on the eastern or the western ansa.

The Outer Ring.—This ring is the great difficulty of the planet, requiring an opportunity of the most choice kind to determine its markings. The lightest portion is certainly on the side next Cassini's division, but does not come close to it, and on the exterior next the sky there is also a faint line of light. This causes an appearance of shade through the central portion of the ring, but no indication of Encke's division could be detected.

39 *Circus Road,*
St. John's Wood.

Mr. Green has presented to the Society a drawing of *Saturn*, as observed by him in 1884.

Observations of Comet 1884 *III.* (*Wolf*) *at Harrow.*

By G. L. Tupman.

The observations were taken with crossed-bar reticule on the $4\frac{1}{2}$-inch equatorial, and power 66. The zero reading of the position circle was carefully determined on eleven nights by a star near the Meridian. The comet had always a well-defined, almost stellar nucleus, which could be very accurately observed. The disappearances and reappearances at the edges of the bars at each transit have been considered as forming a single comparison. The comparisons on Oct. 22, 26, Nov. 18 to end were registered on the chronograph; the others were made by eye and ear. The differences of R.A. and of Declination have been corrected for defective orientation and error of perpendicularity of the bars, for the comet's geocentric motion, and for refraction.

For the parallaxes, log. Δ has been taken from the Ephemeris by Dr. Krueger in the *Astronomische Nachrichten*, with mean solar parallax $8''{\cdot}83$.

1884.	Green. Mean Time.	δ − ✱ Δα	Δδ	No. of Comp.	δ app. α	Par.	δ app. δ	Par.	✱
	h m s	m s	′ ″		h m	s	° ′ ″	″	
Sept. 24	10 38 0	−1 12·81	+6 34·4	11, 11	21 17 23·00	+0·20	+20 36 14·9	+5·8	1 (*a*)
25	9 46 4	−0 22·65	−8 48·8	13, 13	21 17 58·71	+0·10	+20 9 36·8	+5·8	2
27	10 45 50	+2 35·90	−6 30·6	12, 12	21 19 22·53	+0·23	+19 12 31·2	+6·2	3
Oct. 4	9 17 52	+0 19·29	+0 57·6	5, 5	21 25 33·94	−0·12	+15 51 45·5	+6·5	4 (*b*)
	9 59 47	+0 21·28	+0 6·7	6, 6	21 25 35·93	−0·03	+15 50 54·6	+6·5	4
	10 23 34	+0 22·22	−0 18·8	5, 5	21 25 36·87	+0·02	+15 50 29·1	+6·5	4
13	11 29 16	−3 24·43	+2 57·1	9, 9	21 36 55·43	+0·27	+11 23 55·6	+7·3	5
22	9 30 22	+2 55·75	−3 44·0	10, 10	21 51 20·94	+0·20	+ 7 12 30·1	+7·5	6 (*c*)
26	10 4 32	−1 6·71	+1 50·9	19, 19	21 58 49·16	+0·26	+ 5 26 29·8	+7·6	7
Nov. 7	10 27 53	+0 55·72	+4 55·1	12, 12	22 23 56·72	+0·31	+ 0 49 31·3	+7·6	8 (*d*)
8	9 40 20	−0 41·79	−0 39·8	14, 14	22 26 7·06	+0·24	+ 0 30 14·1	+7·5	9 (*e*)
18	9 41 0	−1 31·08	+5 15·3	14, 14	22 49 38·61	+0·25	− 2 22 33·2	+7·2	10
19	6 19 34	+0 35·33	−7 17·5	18, 18	22 51 45·01	−0·06	− 2 35 6·0	+7·3	10 (*f*)
20	9 28 34	−0 9·42	−1 15·7	20, 20	22 54 31·30	+0·23	− 2 50 59·8	+7·2	11
21	5 56 32	−0 11·59	+2 13·1	15, 15	22 56 37·61	−0·09	− 3 2 39·8	+7·2	12
Dec. 9	6 34 15	+0 27·40	+6 47·6	18, 18	23 42 25·41	+0·01	− 5 45 33·6	+6·5	13 (*g*)
15	6 1 59	+0 28·10	−3 14·5	24, 24	23 57 51·95	−0·02	− 6 9 22·5	+6·2	14
1885. Jan. 7	6 48 36	−1 38·77	+2 9·1	11, 11	0 56 56·14	+0·07	− 5 53 15·0	+5·1	15 (*h*)
	6 48 36	−1 51·78	+3 8·8	11, 11	0 56 56·14	+0·07	− 5 53 17·2	+5·1	16
Feb. 5	6 56 43	+0 43·43	+1 22·7	16, 16	2 8 27·66	+0·10	− 3 9 21·7	+4·0	17 (*j*)

Notes.— (*a*) Sept. 24. Comet has stellar nucleus 2″ or 3″ diam., 9½ mag. Coma perhaps 2′ diameter, no tail. Object glass dewed. (*b*) Oct. 4. Coma 2′ diam.; nucleus 2″; 10 mag. No tail. (*c*) Oct. 22. Fog; object glass much dewed. Observations unsatisfactory. Nucleus distinct, 10 mag. Coma large and faint. (*d*) Nov. 7. Moonlight; some haze. Comet is brighter? (*e*) Nov. 8. Comet bright, 4′ or 5′ diam.; nucleus sub-stellar, 11 mag. Fine night. (*f*) Nov. 19. Comet's diameter about 4′. The central condensation is brighter than it was, and larger, perhaps 4″ or 5″. No signs of tail, but the coma is not uniformly luminous. (*g*) Dec. 9. Diameter 5′. Central condensation about same brightness as before. (*h*) Jan. 7. Comet very much fainter. Nucleus still stellar; getting difficult to observe well. (*j*) Feb. 5. Faint and difficult; diameter 1½ or 2′. Nucleus stellar, glimpsed at intervals. Very fine night.

Mean Places of the Comparison Stars.

	1884·0. h m s	s	1884·0. ° ′ ″	″	
1	21 18 32·42	+3·39	+20 29 10·4	+30·1	B.B. vi. +20°·4902
2	21 18 17·98	+3·38	+20 17 55·4	+30·2	Berlin Zones 1881, 2 obs.*
3	21 16 43·29	+3·34	+19 18 31·6	+30·2	9-year, 1997.
	21 16 43·28		+19 18 31·2		Berl. Jahrb.
4	21 25 11·61	+3·30	+15 50 5·2	+30·1	LL. 41860.
	21 25 11·43		+15 50 21·3		W.B. xxi. 550.
	21 25 11·39		+15 50 21·9		Rümker 9228.
	21 25 11·35		+15 50 17·8		Berlin Zones 1870, 3 obs., adopted.†
5	21 40 16·48	+3·27	+11 20 28·9	+29·5	LL. 42432 } P.M. in decl. −0″·315 has been applied.
	21 40 16·77		+11 20 28·8		W.B. xxi. 936 }
	21 40 16·59		+11 20 29·0		Lamont$_4$ 2791 }
6	21 48 22·05	+3·19	+ 7 15 44·8	+28·6	Lamont$_2$ 6182 } mean adopted.
	21 48 21·94		+ 7 15 46·1		BB. vi. 4763 }
7	21 59 52·36	+3·20	+ 5 24 11·2	+28·0	Piazzi xxi. 390.
	21 59 53·00		+ 5 24 12·5		W.B. xxi. 1351.
	21 59 52·67		+ 5 24 10·9		Taylor 10246 (adopted).
8	22 22 57·76	+3·16	+ 0 44 9·9	+26·1	Lamont$_1$ 8848 } mean adopted.
	22 22 57·70		+ 0 44 12·6		Harvard Zones 77,5 }
	22 22 57·92		+ 0 44 10·3		BB. vi. +0°·4878 }
9	22 26 45·74	+3·17	+ 0 30 27·9	+26·0	LL. 44036.
	22 26 45·65		+ 0 30 28·1		Lamont$_1$ 8879.
	22 26 45·56		+ 0 30 27·5		Harvard Zones 73,70.
	22 26 45·68		+ 0 30 27·9		Schj. 9218 (adopted).
10	22 51 6·53	+3·16	− 2 28 12·6	+24·2	Lamont$_1$ 9034.
		+3·15		+24·1	
11	22 54 37·57	+3·15	− 2 50 8·0	+23·9	W.B.$_1$ xxii. 1110.
12	22 56 46·87	+3·15	− 3 5 13·8	+23·7	Lamont$_3$ 4700.
	22 56 46·05		− 3 5 16·6		Peters A.N. 2655 (adopted).
13	23 41 55·30	+3·15	− 5 52 49·1	+20·2	W.B.$_1$ xxiii. 821.
	23 41 55·31		− 5 52 54·4		Rümker 11582.
	23 41 54·86		− 5 53 1·0		Albany Mer. Obs. A.N. 2657 (adopted).
14	23 57 20·69	+3·16	− 6 6 27·1	+19·1	W.B.$_1$ xxiii. 1152.
	1885·0.		1885·0.		
15	0 58 35·00	+0·17	− 5 55 24·4	− 5·3	W.B.$_1$ 0.998.
	0 58 34·74		− 5 55 18·8		A.N. 2657 (adopted).
16	0 58 47·75	+0·17	− 5 56 20·7	− 5·3	A.N. 2657.
17	2 7 44·04	+0·19	− 3 10 35·4	− 9·0	Schj. 649.

* Kindly communicated by Dr. Becker.
† Kindly communicated by Dr. Auwers.

Five orders of Meteor Streams or Comets. By Richard A. Proctor.

The importance of Mr. Denning's discovery (which must now, I presume, be regarded as established), that the members of certain meteor systems radiate sometimes for months in succession from the same point in the star sphere, induces me to make some remarks upon the subject, with the view chiefly of recommending it to the attention of those who have time for the observation of meteors and shooting stars. I am the more disposed to do this because four or five years ago, when as yet Mr. Denning's discovery was not established, I pointed out the startling inferences deducible from it, as reasons for doubting—at that stage of his observations—whether the discovery could be real. Yet, fully twelve years ago, I had indicated a theory respecting the origin of comets and meteor-systems which would point to the belief that the relations resulting from Mr. Denning's discovery must in reality exist, startling though they are.*

It should not be necessary to state, in addressing the Fellows of the Astronomical Society, that Mr. Denning's discovery can bear but one interpretation. It proves that the motion of the Earth in her orbit round the Sun is almost at rest compared with the velocities of the members of those meteoric families which have an unchanging, or a very slightly changing radiant, for months in succession. Without assuming that the radiants can be determined with anything like the precision claimed by Mr. Denning (noticing indeed that if this were possible, then in the case of some meteor systems the effects even of our Earth's rotation could be detected in a change of radiant during a shower lasting five or six hours), it is certain that we have to deal, in the case of the long-lasting radiants, with bodies travelling at the rate of hundreds of miles per second. This is certain, without taking into account the effects of the Sun's attraction in modifying the direction of the movements of these meteors; but as a matter of fact the Sun's attraction cannot greatly alter (at the Earth's distance) the directions of bodies already moving with velocities far exceeding those he can impart. I have shown this mathematically in recent numbers of *Knowledge*, in which the simple but apparently little known mathematical relations involved have been somewhat fully dealt with.

Another point in Mr. Denning's discovery is also significant in the same direction. The point was not necessary to demonstrate what the discovery unquestionably proves; but it affords very interesting independent evidence. The meteors of the kind considered are seen year after year. Now this, which, in the case of systems observable only for a few hours or days at the outside, is a relation very naturally following from what is already known about such systems, has a very different meaning in the case of these meteors with long-lasting radiants. If the

* In my article on "Three Orders of Comets," *Popular Science Review* for Jan. 1873.

Earth passes one year through a meteor system attending on the Sun, she will pass through it, or at least through its orbit, every year. But meteors of the same system seen several months in succession manifestly cannot belong to a family attending on the Sun. Their being seen many years in succession indicates broad-spreading. It is an independent proof, therefore, of the remoteness of the source from which such meteors originally came.

As the new order of meteors detected by Mr. Denning cannot have been drawn to the solar system by the Sun's action, we must certainly reject in their case what some regard (strangely enough) as the accepted theory of meteoric origin,—I refer to Signor Schiaparelli's speculation that flights of scattered bodies are drawn into the solar system by the Sun's attraction, and are caused by planetary attractions to travel in closed orbits. I showed, twelve years ago, that this speculation undoubtedly fails also in the case of the November meteors, and probably for all meteor systems of that class. It was, however, never more than a speculation, and has always been so regarded by all who understand the matter, including those who have most admired the ingenuity displayed by Signor Schiaparelli in first suggesting, and afterwards enforcing, the theory of the connection between meteors and comets, which is now regarded as an established truth.*

But indeed to account for meteor-systems or comets as drawn from out the interstellar depths, is to explain *obscurum per obscurius*. It is antecedently altogether more unlikely (it is an infinitely wilder hypothesis, one may say) that the immensity of interstellar space should be a sort of breeding place for meteor flights, than that meteors should have had their origin in suns or planets. If an explosion like that of Krakatoa scatters earth-dust through millions of cubic miles of air (here I am in no sense adopting the Krakatoa explanation of the coloured sunsets, but simply referring to what certainly happened), the theory that a sunlike body—our Earth in her youth for instance—has expelled meteoric bodies in occasional eruptions through vast regions of interplanetary spaces, or that a Sun like our own has expelled meteoric bodies through yet vaster regions, is simply a theory which presents on a larger scale what we have already recognised as certainly happening on the smaller scale.

Apart from this, Signor Schiaparelli's speculation, after all, according to which meteor flights came from out the star depths, is by no means inconsistent with any theory showing how the meteor flights may have come into those depths.

Mr. Denning's discovery, since it presents meteor flights, or comets, traversing the interstellar depths with velocities far

* As one of those who most earnestly advocated the recognition extended in 1872 to Signor Schiaparelli's theory, it should hardly be necessary for me to explain that what I have said in regard to his speculation has no reference to the validity of his theory.

greater than our Sun can impart by his attractive might—compels us to recognise something more, in *these* meteor flights, any way, than mere space-begotten bodies. Must we not look for the source of these tremendous velocities, evidence as they are of tremendous energies exerted *somewhere*, to those bodies which are the mightiest we know of,—the giant suns?

In fine, I regard Mr. Denning's discovery as completing the evidence respecting comets which I presented in a comparatively incomplete state in my article on 'Three Orders of Comets,' in the *Popular Science Review* for January 1873. At that time I showed that we can recognise three orders of comets, viz.—*First*, those which, since they travel in paths passing near the paths, severally, of the giant planets, were probably ejected from those bodies when severally in the sunlike state; *secondly*, those which travelling in more widely extended paths, pass so near the Sun that they may be regarded as probably ejected from him, and subsequently so perturbed by planetary action as to pass clear of his globe on their return; and *thirdly*, those whose paths show that they were originally ejected from suns like ours. These three orders must now be regarded as respectively the *second*, *third*, and *fourth orders* of meteor flights or comets. Two other orders must be added, viz.:—*First*, those meteor systems whose paths or component elements show that the meteors were originally ejected from our Earth when she was in the sunlike state; and *fifthly*, those whose enormous velocities show that they were originally ejected, not from suns like our own, but from the giant suns like *Sirius*, *Vega*, *Altair*, and others, whose spectra indicate greater energies than exist in our own sun or his fellows,—as *Capella*, *Aldebaran*, *Betelgeux*, and other suns of Secchi's second class.

All that has been learned from the microscopical, chemical, and physical analysis of meteors, can be explained by the theory to which we have thus been led; and much of it can be explained no other way. Moreover, the observation of the Sun has demonstrated the occurrence of precisely such eruptions as this theory indicates.

To sum up, all or most meteor systems or comets would appear to have had their origin in orbs in the sunlike state, and may be classified under five heads, viz.:

First, those sprung from the terrestrial planets
Secondly, those sprung from the giant planets
} when in the sunlike stage of their career.

Thirdly, those sprung from our own Sun.

Fourthly, those sprung from other suns of the same order.

Fifthly, those sprung from the giant suns of the first order.

Other classes probably exist, other sub-divisions certainly.

Galveston, Texas:
1885, *March* 31.

A Peculiar Variety of Meteors. By W. F. Denning.

On the morning of April 20, at 1^h 36^m A.M., while watching the progress of the Lyrids I saw a remarkable meteor, projected apparently on the stars ε and δ of *Serpens*, as it rose upwards with great rapidity in the south. The meteor was about the third magnitude, but the singularity about it was its marvellous velocity and seeming nearness. It appeared to be in the air, a few yards distant, and I believe its path, extending (as it instantaneously impressed me) over some 16° on the background of the sky, must have been traversed in less than the twentieth part of a second. Of course there is a great difficulty in estimating such short intervals, but I feel confident the duration was even more transient than that assigned.

Now and then I have observed similar meteors before. They immediately strike one by their close proximity and enormous velocity. They are mere gleams of pale white light, which have little analogy to ordinary shooting stars, and suggest an electric origin, though I do not know whether the marvellous quickness with which they flash upon the eye is not to be held responsible for the sensation of nearness. They are somewhat rare, and one may watch through several whole nights without a single example, but, as far as my memory serves, I must have witnessed some scores of these meteoric flashes. I never register the paths; they are so rapid as to make but a vague impression on the retina, and the direction is necessarily much involved in doubt. As to the meteor of April 20, it ascended in *Serpens* from the western boundaries of *Scorpio*, and probably diverged from a radiant near the bow of *Sagittarius*. It was the only one I saw of the kind alluded to, or which could have belonged to a radiant so low in the S.E. amongst eighty-one meteors recorded during the nights of April 18, 19, and 20, 1885.

I have consulted several catalogues for notices of abnormal meteors such as the one described, but in most cases there is an absence of individual notes, and I have failed to gather much evidence of the kind required. But a most excellent instance, and I think the only one, is referred to in Col. Tupman's catalogue of nearly two thousand shooting stars observed by him while cruising in the Mediterranean during the years 1869–71. The particulars are:—

1870, January 9, 14^h 59^m; mag. 3; path from 169° + 20° to 157° − 10°; length 31°; duration 0·1 second. "An instantaneous flash; seemed to be in the air, quite near. Very curious."

It will be seen that Col. Tupman's description is very similar to my own. Though his meteor had a path of no less than 31°, he estimated the duration as only the tenth of a second.

On the whole I incline to the belief that meteors of this abnormal class give the idea of great nearness as the result of their astonishing speed, and that they will be invariably found

directed from radiants close to the Earth's apex. Their appearance, however, is such as to vividly impress the observer as to their special character. It therefore seems desirable to mention the circumstances, so that workers in this department may record such further instances as they may notice, notwithstanding the uncertainty attached to the path directions of such very transient phenomena. It is just possible they may indicate a form of meteoric display essentially different to that commonly understood.

Bristol: 1885, *April* 27.

Observing Weather. By Rev. S. J. Johnson.

In the last report of U.S. Naval Observatory, Washington, it is stated (p. 9): "A record has been kept by the various observers and the watchmen of the condition of the sky as regards seeing. From this, it appears that but 126 nights were clear enough for observing, and of these but 38 are recorded as good, the remaining 88 being poor or indifferent." For the last quarter of a century I have recorded the number of evenings fit for observation in the western parts of England. In this respect we appear somewhat less favoured than the Americans. By evenings fit for observation, it is inferred that the sky was clear, or with a few small passing clouds, till about 11^h, or else thoroughly clear for a full hour. Clearness of the atmosphere alone is regarded in the following list, not suitability for dividing very close double stars.

The number of nights was as follows:—

In 1859 =	60	nights.	In 1868 =	62	nights.	In 1877 =	60	nights.
1860	44	,,	1869	58	,,	1878	86	,,
1861	46	,,	1870	112	,,	1879	71	,,
1862	46	,,	1871	98	,,	1880	96	,,
1863	47	,,	1872	90	,,	1881	110	,,
1864	83	,,	1873	82	,,	1882	90	,,
1865	82	,,	1874	113	,,	1883	101	,,
1866	77	,,	1875	100	,,	1884	100	,,
1867	55	,,	1876	115	,,			

To give each separate month would occupy space, but it may be stated that the number of clear nights varied from 18 in August 1870 and 17 in May 1876, to one night only in September 1866 and January 1869.

Melplash Vicarage,
Bridport: April 7.